Proposal

Livestock Genetics Flagship

21 July 2016

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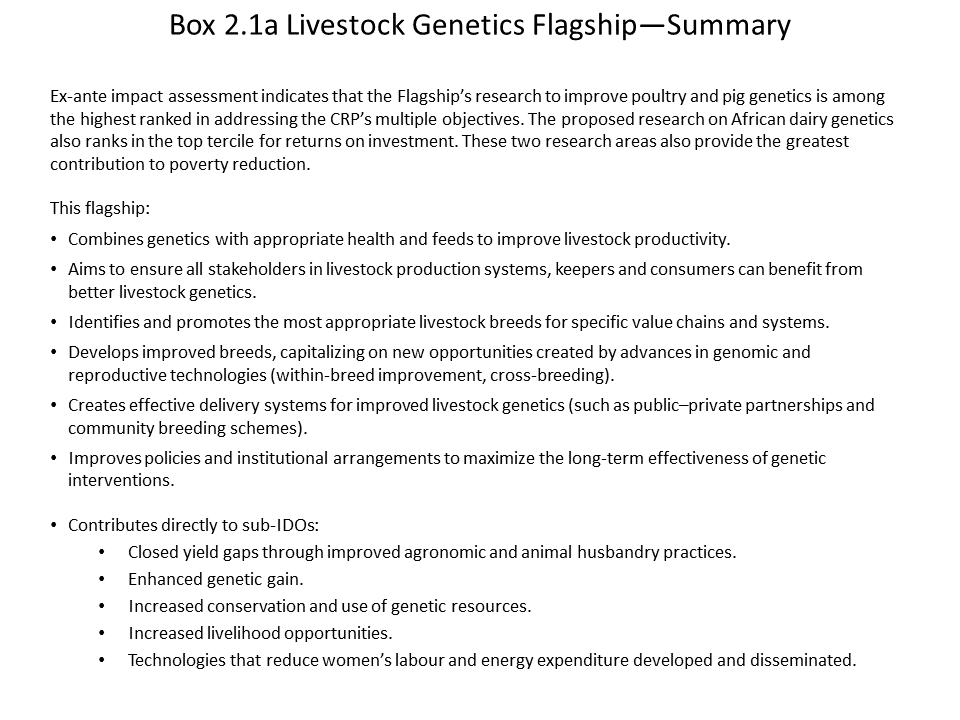
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2.1. Livestock Genetics



### 2.1.1 Flagship Project Narrative

#### 2.1.1.1 Rationale and scope

**Why research on livestock genetics in developing countries?**

Demand for livestock products is increasing against a background of rapid change in the agricultural sector, genetic erosion of indigenous livestock diversity, and increasing impact of climate change.

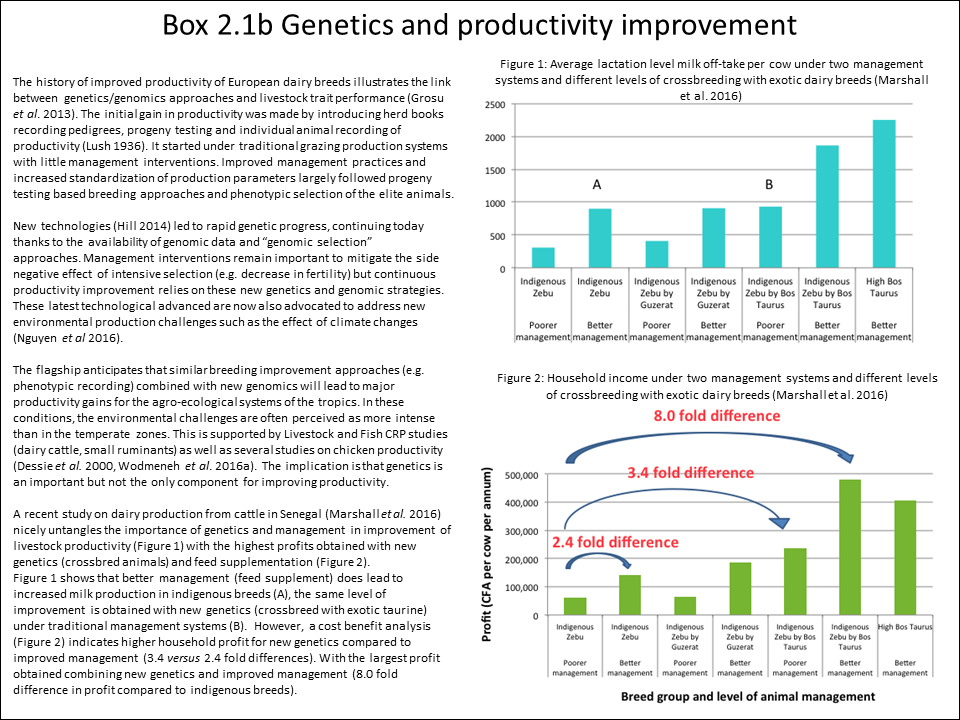
In developed countries, improved livestock genetics associated with better husbandry—better feeds, health care and housing—resulted in significant and sustained increases in livestock productivity. Today, new technologies, including better recording of production traits, statistical models to predict genetic merit, genetic marker information in selection programs (Henderson, 1975; Goddard and Hayes, 2007; Clark and van der Werf, 2013) and new reproductive technologies that speed up genetic gains (Kasinathan *et al.,* 2015) are leading to further productivity gains.

This is not happening in developing countries (Marshall, 2014) for many reasons including: (*i*) until recently, a lack of understanding of the potential of indigenous livestock genetic resources for productivity improvement; (*ii*) investment prioritized other avenues of livestock development; (*iii*) heterogeneity of livestock systems and preferences of livestock keepers; (*iv*) lack of supportive policies, institutional arrangements and capacity to undertake genetic improvement (Kosgey and Mwai, 2007; Rege *et al.,* 2011; Marshall *et al.,* 2013).

This flagship aims to address these issues and to apply new genetics and genomics opportunities to the developing world (ISPC 2014). This builds on the recently increased recognition that genetic improvement in low-input smallholder livestock production systems, when combined with appropriate management strategies, represents a significant and largely untapped opportunity to increase livestock productivity (Thevasagayam, 2013).

Indigenous livestock breeds have sustained human livelihoods for centuries (Okeyo *et al.,* 2015). Today the world faces the challenge to respond quickly yet sustainably to a rapid increase in demand for livestock products, while addressing the poverty and poor nutrition typically found in livestock-producing households. Building on lessons learned from the Livestock and Fish CRP, (e.g. pigs in Uganda and Vietnam, small ruminants in Ethiopia, dairy cattle in Tanzania) and recognizing that successful improvement of productivity is a multi-dimensional challenge, the flagship proposes to apply new genomics technologies, knowledge and breeding approaches to livestock so they address yield gaps and create new livelihood opportunities in the [short to medium term](http://research.csiro.au/livegaps). It will explore and use crossbreeding and breed replacement strategies to achieve productivity improvement within the timeframe of the CRP. Examples of the opportunities for and role of genetic and genomic improvement are given below in Box 2.1b

Most flagship work will target 5 species in 5 priority countries and other locations, namely chickens in Ethiopia, Tanzania and Nigeria; pigs in Uganda and Vietnam; sheep and goats in Ethiopia; and dairy cattle in Ethiopia and Tanzania. It will mainly concentrate on the ‘rapid inclusive growth’ trajectory, since it is here that genetic gains are likely to find their maximum expression in more productive animals in more efficient, intensive and market-oriented systems. Improved genetics, delivery approaches in particular, will also relate to the ‘fragile growth’ trajectory, where there is demand for more resilient and reliably productive livestock leading to better food and nutritional security and resilience to environmental risks.



***Addressing the grand challenges***

The flagship will impact on the grand challenge of climate change: by increasing livestock productivity (though the use of improved genetics, including better feed conversion) greenhouse gas emission intensity will decrease (mitigation) (Gerber *et al.,* 2011; Gerber *et al.,* 2013). By targeting genetic improvement strategies to produce productive and resilient livestock, livestock will remain fit for future environmental conditions (adaptation) (Hayes *et al.,* 2013); provide nutritious and diverse agri-food systems and diets (increasing the availability of animal-source food); and improve food safety (disease-resistant breeds will lower drug load in food products and reduce zoonoses).

Increased livestock productivity, will lead to a relative reduction in the number of animals kept, lowering competition for land and potentially decreasing the risk of soil degradation and of overdrawn and polluted water supplies. Increasing productivity could also make a contribution to reducing malnutrition, providing vulnerable groups (the rural and urban poor) are targeted.

Genetic improvement strategies can contribute to adaptation to climate change, through selection for such traits as drought or heat tolerance. By ensuring that its genetics research reflects the needs of women and young people, the flagship will also, indirectly, tackle the problems associated with age and labour in agriculture. It will make a direct and sizeable contribution to animal genetic resources conservation, by documenting their diversity at genome level and by utilizing it in its breeding programs. Work on policy guidelines and advocacy addressing livestock conservation issues, together with the repositories with *in-silico* data and *ex-situ* material will also impact on diminishing genetic resources.

***Why should CGIAR invest in this?***

CGIAR provides a unique conducive environment in which to develop and deliver a genetic, genomic and breeding program targeting developing countries. ILRI and ICARDA scientists have relevant in-house expertise and successful track records in these areas and convene a strong partner network, including with national systems in animal breeding and genetics who in some cases would be unlikely to achieve the same outcomes working alone. ILRI–Nairobi, the BecA-ILRI hub has up-to-date genetics, genomics and bioinformatics infrastructure and facilities.

**From the ex ante impact assessment, research to improve poultry and pig genetics is among the highest ranked in addressing the CRP’s multiple objectives. The proposed research on African dairy genetics also ranks in the top tercile for returns on investment. These two areas also provide the greatest contribution to poverty reduction (see Annex 3.10.2).**

***Overall goal***

The overall goal of the flagship is to ensure that, by 2022, appropriate livestock breeds are readily available, affordable and widely used by poor women and men livestock keepers, resulting in increased livestock productivity, improved food and nutritional security, better livelihoods and improved natural resource management.

#### 2.1.1.2 Objectives and targets

This flagship addresses the SLOs reduced poverty and improved food security for nutrition and health in smallholder and pastoral livestock systems. It does so through two IDOs, increased productivity and increased income and employment. It directly addresses 5 sub-IDOs: closed yield gaps through improved agronomic and animal husbandry practices; enhanced genetic gain; increased conservation and use of genetic resources; increased livelihood opportunities; and technologies that reduce women’s labour and energy expenditure developed and disseminated.

The program recognizes that livestock genetics lies at the root of other successful, sustainable and cost-efficient interventions in the livestock sector which, when working in synergy, will maximize its impact. The flagship advocates that the present genetics of livestock species is a main limiting factor for improvement of productivity and thus include a portfolio of genetic interventions such as within indigenous breed improvement (small ruminants, chickens), crossbreeding (dairy cattle) and breed replacement (chickens). The flagship will therefore collaborate with the Livestock Health and Livestock Feeds and Forages flagships to investigate the interface between animal health, genetics and feeds (e.g. responses to vaccination, feed conversion ratio), with the Livestock and Environment flagship to examine responses to changing environmental conditions, and with the Livestock Livelihoods and Agri-Food Systems flagship to optimize livestock systems for productivity and resilience. Outside the livestock CRP, the interaction of livestock with human health, including the impact of breeding zoonotic disease-resistant livestock, will be explored with A4NH. The impact of climate change on livestock performance and genetic improvement strategies will be modelled with CCAFS.

The flagship will directly address national, regional and international livestock research and development priorities. For example, at national level in Ethiopia, it follows the strategies of the Ethiopian Livestock Master Plan (Shapiro *et al.,* 2015), which recommends research on improved pure-line local and crossbred poultry and crossbred cattle, together with expansion of the successful community-based small ruminant breeding improvement program developed in the Livestock and Fish CRP (Shapiro *et al.,* 2015). At the regional level, the flagship responds to and supports decision-making by the African Union Interafrican Bureau for Animal Resources (AU-IBAR), in particular within the scope of its Strategic Priority 2: Strengthening the capacity of African countries in the conservation and use of African [animal genetic resources](http://au-ibar.org/library/publications/365-en/media/press-releases/angr/431-strengthening-the-capacity-of-african-countries-to-conservation-and-sustainable-utilisation-of-african-animal-genetic-resources). The flagship also aligns with the recommendations of the second Global Conference on Agricultural Research for Development, responding, from a livestock genetics perspective, to the request to reshape agricultural research so that it better meets the needs of resource-poor smallholder farmers. Last but not least, it may be expected that the flagship’s activities will also largely follow the priorities of the ongoing GCARD3 (2015–2016) consultation, with, for example, a strong focus on gender and youth.

The flagship’s objectives are:

* Identify and promote the most appropriate existing livestock breeds for systems and value chains (including promotion of breed substitution as relevant).
* Develop improved breeds, capitalizing on recent advances in genomic and reproductive technologies (within-breed improvement, cross-breeding).
* Develop effective delivery systems (public–private partnerships, community breeding schemes).
* Seek improvements in relevant policies and institutional arrangements.

Flagship outcomes to 2022

* 790,000 , 20,000 , 20,000 and 115,000 livestock keeping households (representing 3.7 million , 84,000 , 115,000 & 600,000 individuals, respectively) realizing a 30-50% increase in income, on average, of the household enterprise from chicken, pigs, small ruminant and dairy cattle, respectively, through the use of genetically improved livestock combined with other appropriate animal husbandry practices, across 5 countries.
* 1.5million, 40,000, 45,000 and 230,000 livestock keeping households realizing an 20-25, 20-25, 5 and 20-25% increase in productivity, on average, for chicken, pigs, small ruminants, and dairy cattle, respectively, through the use of genetically improved livestock combined with other appropriate animal husbandry practices, across 5 countries.
* 1.5million, 40,000, 45,000 and 230,000 livestock keeping households realizing an 50-100, 25-50, 6-12 and 50-100% increase in genetic gain, on average, for chicken, pigs, small ruminants, and dairy cattle, respectively, through the use of genetically improved livestock, across 5 countries.
* Guidelines on policy and institutional arrangements for informing breed improvement and conservation options adopted by policy-makers and/or national research partners for one or more species in 4 countries, influencing the practices of 2.2 million livestock keeping households.
* 3.6 million; 50,000; 70,000 and 230,000 women, across 5 countries, enjoy 5-10% increase in returns to their labour, on average, for chicken, pigs, small ruminants and dairy cattle, through the use of genetically improved livestock combined with other appropriate animal husbandry practices.

#### 2.1.1.3 Impact pathway and theory of change

Figures 2.1a and 2.1b present the flagship’s ToC and assumptions. The flagship seeks to ensure that resource poor women and men livestock keepers, as well as others in livestock value chains, can access and equitably benefit from improved livestock genetics. It responds to key animal genetics challenges and opportunities related to the two Livestock CRP trajectories:

* For the rapid inclusive growth trajectory, where livestock keepers are most able to access the inputs needed for expression of genetic potential (such as animal health-care and feed), there is an opportunity to increase livestock productivity through the provision of genetically superior livestock for productive traits, whilst ensuring the livestock remain well adapted to the environment under which they perform.
* For the fragile growth trajectory, where productivity is limited by harsh environments and scarce resources, opportunities lie in ensuring that livestock are reliably productive, highly resilient, and that they retain sufficient functional genomic diversity to continue adapting to new environmental challenges.

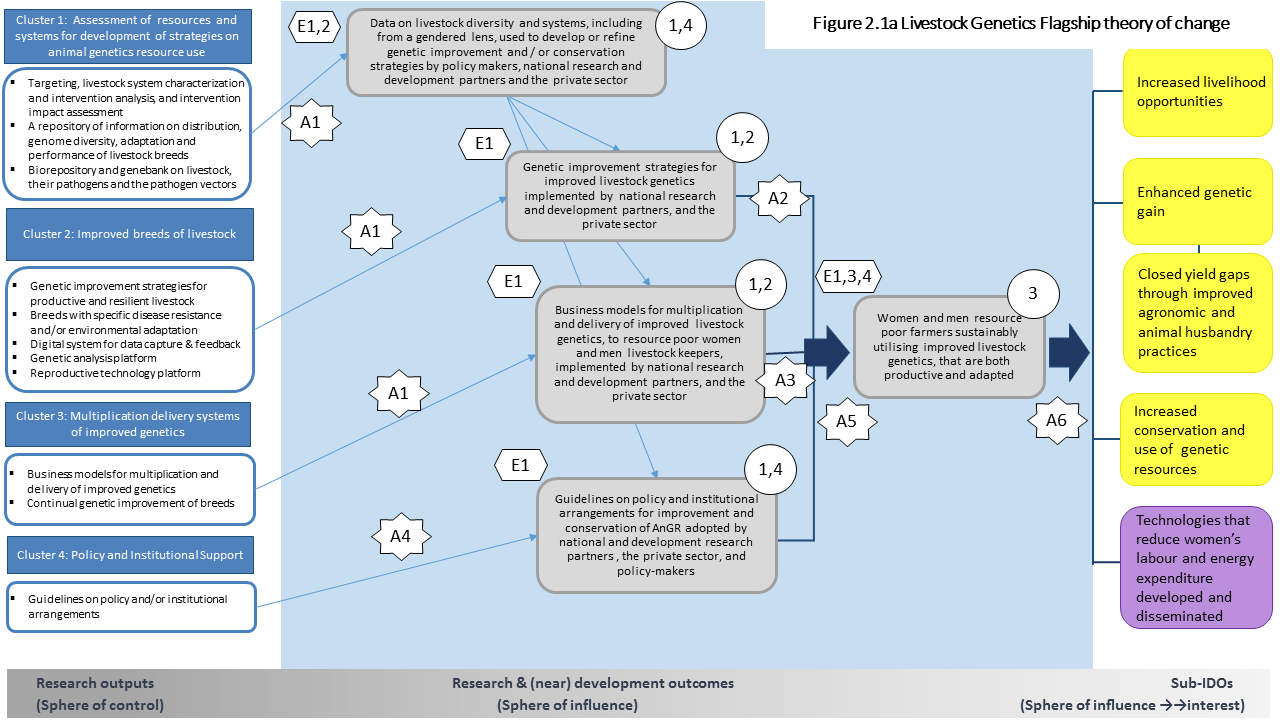
To respond to these opportunities the flagship will identify the most appropriate genetic improvement strategies in conjunction with national policymakers, research and development partners, the private sector and other stakeholders. These may consist of different avenues and approaches, including breed-substitution, within-breed improvement, cross-breeding, or the development of new breeds through the use of genome editing. Productivity jumps in dairy cattle and chicken will arise from identification of more productive genotypes and their distribution at large geographic scale. For small ruminants, slower but continuous gains across generations are anticipated through breed/population selection approaches. The strategies will consider the needs and preferences of women and men livestock keepers and other stakeholders, the present and future conditions of the production system, including the effects of climate change, mechanisms to ensure long-term sustainability, and the required scale to achieve impact. The identified strategies will be implemented together with partners, first at pilot-scale and then at national or sub-national levels. In tandem, delivery systems for improved livestock genetics will be implemented by national research and development partners and the private sector, ensuring accessibility of the improved livestock genetics to livestock keepers. Supporting these genetic improvement strategies and delivery systems will be guidelines on policy and institutional arrangements for improvement and conservation of animal generic resources, developed with, and adopted by, research partners, the private sector and policymakers. Attention will be paid to enabling conditions and actions needed for women and men livestock keepers to capitalise on their investment in improved livestock genetics. Embedded in all these steps are the capacity development of partners and stakeholders. Previous lessons have shown that without these any genetic improvement programs will be short-lived and/or of insufficient scale to achieve substantial impact (FAO, 2010).

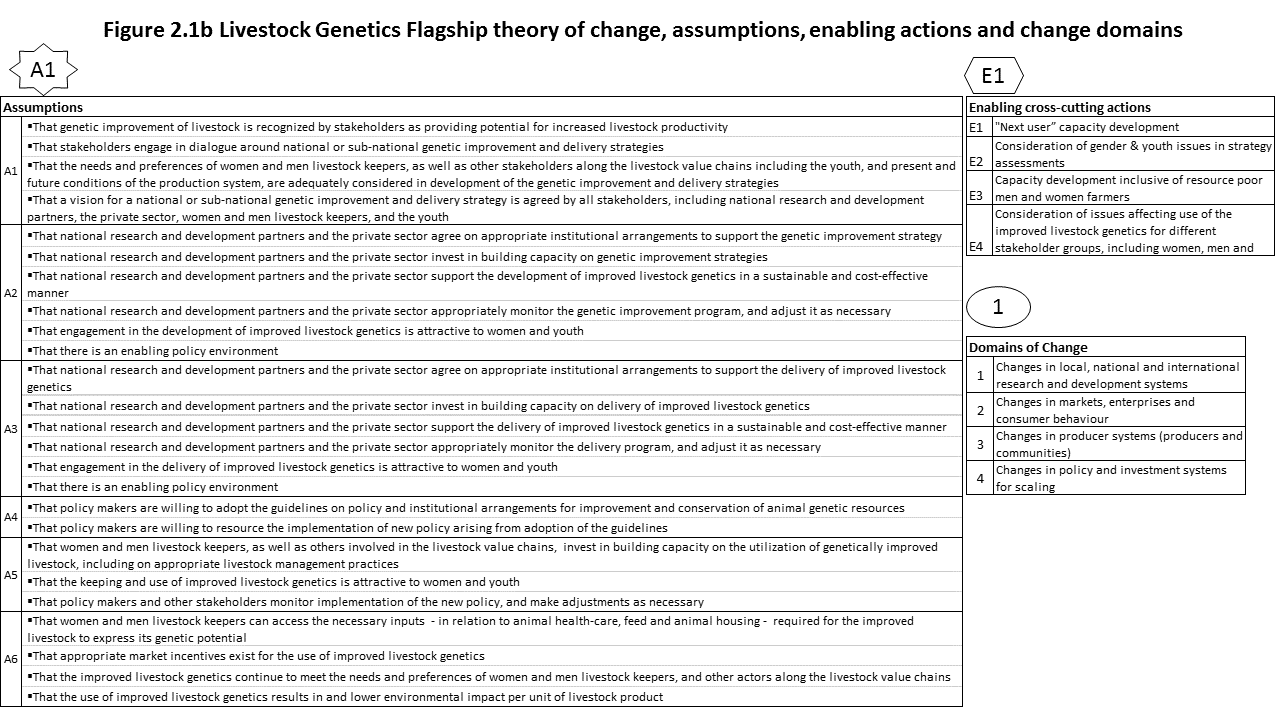
To further support these changes, the flagship will produce several international public goods (IPGs), including models for genetic improvement in developing country livestock productions systems, improved breeds of livestock, and publicly available data (on livestock systems, livestock performance and livestock genomic diversity).

The changes above will happen because: a vision for a genetic improvement and delivery strategy will be agreed by all stakeholders, including national research and development partners, the private sector, and other stakeholders; and national research and development partners and the private sector will invest in building capacity on genetic improvement and delivery strategies, and support the development and delivery of improved livestock genetics in a sustainable and cost-effective manner.

Previous work in the Livestock and Fish CRP revealed that these assumptions are appropriate and will support these changes among ‘next users’ of the outputs. This process is already initiated in Ethiopia, Tanzania and Nigeria; partnerships were established, genetic improvement and delivery strategies identified, capacities began to be built, and pilots initiated. In these sites, the focus will be completion of the pilot testing, further strategy refinement and capacity building, and scaling-out. In Uganda and Vietnam, work is at an earlier stage and the focus will be on identifying appropriate genetic improvement strategies and their piloting.

The flagship believes that the changes across different domains of ‘next users’ will contribute to development outcomes of: increased livelihood opportunities, enhanced genetic gain, closed yield gaps, increased conservation and use of genetic resources, and increased returns on women’s labour and energy expenditure. For this to happen, women and men livestock keepers will access feed and health inputs required for the improved livestock to express their genetic potential, and appropriate market incentives for the use of improved livestock genetics will exist and to ensure uptake by women and youth, improved livestock genetics and their delivery systems must be attractive to these users.





#### 2.1.1.4 Science quality

The flagship hypothesizes that informed utilization in breeding programs of functional genome diversity found in indigenous and exotic livestock breeds will lead to major productivity jumps in intensifying systems, while retaining and improving adaptive ability in more fragile systems. Previous successful examples include in the developed word the Myostatin gene (Grobet *et al.,* 1997) in cattle and in the developing world the prolificacy Booroola genes in sheep (Nimbkar *et al.,* 2005). A further hypothesis is that the diversity present in indigenous livestock and crossbreeds will allow continuous genetic gains down the generations, through the design of tailored breeding programs. These are reasonable assumptions. Indeed, recent developments in genomics, phenotypic recording, and breeding and reproductive technologies provide new opportunities for innovative applied research in these areas. However, these technologies remain so far mainly in the developed world and emerging economies, where they have mainly benefited the commercial sector. Links between genetics/genomics approaches and livestock trait performances have been extensively documented for the commercial improved livestock breeds (see Hill, 2014 for dairy cattle, Dekkers *et al.,* 2011 for pigs, and Martins *et al.,* 2012 for broiler chickens).

The flagship strategically includes relevant proven scientific developments and technologies as well as partnerships with advanced research institutes, for example:

1. The flagship will intensively use genotyping tools and develop its own as required, including new generation sequencing and array genotyping technologies that allow probing the entire or targeted region of the genome of an animal at relatively low cost[[1]](#footnote-1).
2. The flagship will overlay livestock diversity with geo-referenced multi-scale and multidisciplinary data on livestock production systems, allowing a range of analyses including modelling in the field of livestock landscape genomics (Stucki *et al.,* 2014a; Stucki *et al.,* 2014b; Joost *et al.,* 2010).
3. The flagship will further develop the ILRI [biorepository](http://azizi.ilri.cgiar.org/) of geo-referenced biological samples linked to genome sequences, gene expression, phenotypes, etc.
4. Novel phenomics approaches, as a means of measuring the physical and biochemical traits of animals (e.g. the use of rumen boluses with sensors to monitor rumen condition; automatic recording of respiration rates as an indicator of adaptation to heat stress, etc.) will be combined with the use of mobile phone-based applications to record animal measurements and provide feedback. These will narrow information gaps on livestock performance and provide feedback to farmers, who will have an evidence base for making informed management decisions (Houle *et al.,* 2010; Wanga *et al.,* 2015).
5. The flagship will also apply new and improved genome analysis tools to improve the understanding of the genes and gene networks (genomic architecture) underpinning important livestock traits such as resilience and disease resistance (Rothschild and Plastow, 2014; Bishop and Woolliams, 2014; Boettcher *et al.,* 2014).
6. Genetic markers and genome-wide selection approaches will be implemented (e.g. genomic selection in crossbred animals) (Goddard and Hayes, 2007; Clark and van der Werf, 2013), and genome editing and precision breeding approaches (CRISPRs and TALENs) will be applied to capitalize on recent genome architecture and diversity discoveries (Hackett *et al.,* 2014; Carlson 2014).
7. The flagship will explore and pioneer advanced reproductive technologies relevant to developing country livestock systems, for example the use of primordial germ cell technology for indigenous village chicken (Nakumura *et al.,* 2013), and the optimization of semen viability and delivery in dairy cattle.
8. The flagship will also continue to develop novel sequence-based technologies as a means of identifying and quantifying pathogen burdens in African livestock and linking these to animal genotypes, in collaboration with the Livestock Health flagship. Joint research with the Livestock Feeds and Forages flagship will be conducted on the relationships between livestock breed-type, feeding regimes and productivity.

Program partners recently partnered with the University of Edinburgh and Scotland’s Rural College to establish a joint Centre for Tropical Livestock Genetics and Health (CTLGH). This new centre is at the core of the flagship’s strategy for achieving scientific quality. The partnership, as well as others with advanced research institutes such as the University of Nottingham and Wageningen UR will ensure that the program’s livestock breeding programs benefit from the latest scientific developments in the fields of genomics and reproduction. These will be expected to catalyse the scientific quality and impact of the flagship’s work[[2]](#footnote-2).

Results will be co-published in high-impact peer-reviewed and open-access journals, and in other forms as appropriate. Staff from these academic institutions will either lead or participate in genomics and animal breeding training programs. The CTLGH partners will also oversee the establishment of new technological platforms at ILRI laboratories, as well as help to strengthen existing platforms (e.g. genome editing and primordial germ cell technology platforms). These institutions will also provide focal points for the registration of ILRI project students at post-graduate levels (MSc and PhD).

The flagship may also partner with the CGIAR Genetic Gains platform, in particular its modules on bioinformatics and data management tools. For the genotyping and sequencing tools and services, it will team up with private companies when they provide quality service at lower cost than CGIAR facilities. It will make use of the BecA-ILRI hub genomic facilities, holding relevant capacity development activities on livestock genomics and bioinformatics. All these partnerships will complement this flagship’s critical scientific mass, as well as provide access to up-to-date genomics and bioinformatics facilities.

#### 2.1.1.5 Lessons learned and unintended consequences

This flagship will build heavily on initiatives undertaken in the first round of CRPs, but take into account lessons learned over the years while capitalizing on new technologies and approaches.

Examples of previous projects include:

1. Dairy genetics projects in East Africa and Senegal, which demonstrated the productivity increases possible in smallholder dairy herds when appropriate crossbred animals are used (Ojango *et al*,. 2014; Marshall *et al.,* 2016). This CRP will considerably expand the scope of these studies by increasing the number of crossbred animals being genotyped and by developing new low-cost genetic screening tools.
2. Community-based breeding programs for small ruminants in Ethiopia, which demonstrated the feasibility of this breeding strategy for improvement of meat productivity in low-input systems and highlighted the need for supporting institutional arrangements to ensure sustainability (Muller *et al.,* 2015; Gizaw *et al.,* 2014). This flagship will focus more on supporting policy and institutional arrangements, but also expand this approach to more populations and breeds in Ethiopia, and in North African countries including Morocco.
3. A pilot project for a [mobile phone-based data capture](http://data.ilri.org/tools/dataset/tiac) and feedback system on livestock performance, which showed the viability of this technology but also the importance of providing sufficient farmer incentives for participation. The flagship will adopt tablet or mobile phone-based data capture for its chicken and dairy cattle projects.
4. A project established a platform for transgenesis from which a cloned bull was generated as proof of concept (Yu *et al.,* 2013). This flagship will complement this work by establishing a platform for genome editing. This may be more easily accepted by the general public than transgenesis and might therefore be prioritized during implementation of the new CRP.
5. The value chain assessments under the Livestock and Fish CRP indicate the lack of data as a basis for making strategic decisions on conservation and use of animal genetic resources (Lagese *et al.,* 2014; Ouma *et al.,* 2015; Sikira *et al.,* 2013). The flagship will respond to this by conducting large-scale livestock genome diversity studies, as well as more market studies for individual livestock products.

The flagship will monitor potential unintended consequences of its interventions and address these. For example:

1. If farmers raise the same number of more productive livestock, this may increase the pressure on natural resources. This will be addressed by working with the Livestock and the Environment flagship on monitoring and introducing mitigation interventions.
2. The contribution of improved livestock genetics to intensification may result in the movement of some livestock keepers out of livestock, and the introduction of business models to deliver superior livestock genetics may displace some current providers of this service. This will be managed by working with the Livestock Livelihoods and Agri-Food Systems flagship to provide opportunities for alternative livelihood options.
3. Promotion of superior livestock genetics could negatively affect livestock biodiversity, particularly in relation to indigenous livestock. This will be mitigated by the promotion of conservation strategies, including *in silico* through the full genome sequencing of the diversity of the livestock population concerned.
4. Introduction of livestock with altered genomic sequences may raise public concerns, which will be addressed by engagement with national counterparts, public awareness and the provision of evidence.

#### 2.1.1.6 Clusters of activity

The flagship is organized in four interlinked clusters of activities. Cluster 1 will provide necessary knowledge and information on livestock and their production systems. These are needed for the successful implementation of cluster 2, which deals primarily with enhanced genetic gains to close the yield gap. Cluster 3 addresses the issue of continuous genetic gains and medium- to long-term sustainability. Finally, cluster 4 deals with the enabling policy and institutional environment that is equally essential for long-term sustainability. These clusters were developed recognizing the important roles that women, men and young people play in livestock production, and they all include strong capacity development components (see the Impact Pathway and ToC section).

W1/W2 as well as substantial W3/bilateral funding will support the activity clusters. The flagship’s W1/W2 fund will support the key research elements for the delivery of the 3 sub-IDOs, with W3/bilateral funding supporting more downstream activities (e.g. dairy cattle and chicken projects). This W1/W2 funding will also be used to protect key research (e.g. on small ruminants, pigs) while bilateral funding sought. As needed W1/W2 will be used for new, exploratory and pilot research activities.

Cluster 1: Assessment of resources and systems for development of strategies relating to the conservation and use of animal genetic resources

Better targeting of genetic interventions requires improved knowledge of the systems in which animal genetic resources are used, the phenotypic and genetic characteristics of the resources themselves, and of the broader economic, social and environmental contexts. This activity cluster aims to obtain this information (where it does not yet exist), as a basis for designing better tailored and more appropriate genetic interventions. The approach will involve a broad system assessment complemented by detailed assessments of animal genetic resources and their uses, including productivity and adaptation traits, both studied at the phenomic and genomic levels.

A unique livestock biorepository located on the ILRI compound in Kenya, of mostly geo-referenced biological samples that are linked to genomic sequences, gene expression, performance and other information, will be further expanded (new samples) and developed (use of new genome technologies for analysis of the samples). This asset which is primarily a resource for the study of genetic variation and functional genomics in livestock species, has proven to be invaluable in providing opportunities to access samples and information collected over decades, that can be analysed to provide new information on the genetics underpinning important livestock production and resilience traits. ILRI’s Domestic Animal Genetic Resources Information System ([DAGRIS](http://www.dagris.info)), will be linked to the biorepository through information geo-referenced in both databases. Such integration will facilitate modelling of livestock diversity, the identification of livestock populations with unique adaptive traits as resource populations for genomic architecture studies, evidence-based predictions of livestock performance under a future changed environment, and improvement and better matching of livestock breeds to production systems/environments.

The flagship is building on the Livestock and Fish CRP where piloting testing of genetic improvement programs and linked delivery systems were initiated for chicken, goats and sheep, and dairy cattle. Best-bet interventions identified from these various assessments will be shared with stakeholders for joint agreement on which ones potentially take to scale. Targeted systems characterization, as well as gender-sensitive *ex-ante* and *ex-post* impact assessments of interventions, will be performed, resulting in better targeted, selected and monitored genetic interventions, and documented lessons. As a component of this, trade-off assessment will be performed in relation to the keeping of different livestock breeds/genotypes (considering, for example, intra-household livelihoods and environmental sustainability).

Given the strategic and baseline nature of the research activities within this cluster, W1/W2 funds will support all 3 main research outputs as required for successful delivery.

Main research outputs

* A repository of information on the distribution, genetic diversity, adaptation and performance of livestock breeds in developing countries, linked to information on the systems in which they perform.
* [Biorepository](http://azizi.ilri.cgiar.org/) of biological material and genome sequences of livestock, their pathogens and pathogen vectors.
* Livestock system characterizations and intervention analyses, together with impact assessments**,** for development of strategies on animal genetic resource use.

**Outcomes by 2022**

1. Data on livestock diversity and systems, including from a gendered lens, used to develop or refine genetic improvement and / or conservation strategies by policymakers, national research and development partners, and the private sector, in 5 priority countries and other locations.

Milestones

* Data on livestock diversity and systems used to develop or refine genetic improvement strategies in 3 priority countries and other locations (2019).

Cluster 2: Improved breeds of livestock

Improved livestock genetics will increase productivity and resilience and decrease the impact of animal diseases, including zoonoses.

This cluster of activities aims to promote or develop superior genetics, so as to increase the availability of breeds that fit the needs and preferences of women and men livestock keepers, other actors within the livestock value chain or system, and consumers, both now and in the future. The approach will be tailored to the livestock species, system characteristics and stakeholder requirements of specific production systems. Options include increasing the genetic merit of existing populations through within breed improvement programs, breeds substitution and the introduction of improved breeds (for use either as pure-breds or crossed with existing populations) for pilot testing and scaling up, or the creation of improved breed types through innovative approaches such as genome editing. In particular, the genome editing approach will be tested for its value in producing livestock with specific adaptive attributes or disease resistances. Targets include cattle resistant/tolerant to infection with African trypanosomiasis and East Coast fever, and pigs resistant to African swine fever.

Genetic improvement strategies for productive and resilient livestock will be piloted and then scaled up at national or sub-national level. They will be monitored and adjusted as needed. Supportive policy measures and capacity building will help to ensure sustainability (cluster 4).

Information technology will play an important part in engaging the participation of producers in improving their own animals. Hand-held devices and mobile phone-based data capture and feedback systems on animal performance will be refined, such that livestock keepers can make routine assessments of performance and take evidence-based management decisions, including decisions on breeding. Special attention will be paid to ensuring that different socio-economic groups, including women and young people, can have access to and benefit from this system. Given the technological nature of this activity, there is a real opportunity for young people. Analysis platforms will complement the data capture and feedback system. These will be able to capture and merge data from individual farmers into collective datasets, perform analyses to identify genetically superior animals, and generate the feedback for delivery to farmers. In combination, the data capture and feedback systems, and the linked analysis platforms, will underpin national livestock genetic improvement efforts.

A reproductive technology platform as a tool for germplasm multiplication, dissemination and conservation will be further developed in this cluster, at the BecA-ILRI hub. This platform will be supported and used by research programs from the CTLGH.

This cluster of activities has attracted substantial bilateral funding. W1/W2 will be used to ensure delivery of the outputs and the more upstream research components of the activities.

Main research outputs

* Genetic analysis systems for identifying genetically superior livestock.
* Breeds with specific disease resistance and/or environmental adaptation.
* Genetic improvement strategies for productive and resilient livestock.
* Digital systems for capture and feedback to farmers of data on animal performance further tailored to specific systems.
* Reproductive technology platform to support the creation and conservation of improved livestock breeds.

Outcomes by 2022

1. Genetic improvement strategies for improved livestock genetics implemented by national research and development partners, and the private sector in 6 priority countries and other locations.

Milestones

* Genetic improvement strategies for improved livestock genetics implemented at pilot levels in 4 priority countries and other locations (2019).
* Data on livestock diversity and systems, through a gendered lens, used to develop or refine genetic improvement and/or conservation strategies by policymakers, national research and development partners and the private sector, in 3 priority countries and other locations (2019).
* Genetic improvement strategies for improved livestock genetics implemented at pilot levels in 2 additional priority countries and other locations (2022).

Cluster 3: Continuous genetic gains, multiplication and delivery systems

In the previous cluster, the objective is to identify, develop and promote genetically superior livestock. In this cluster, the aim is to continually improve the performance of these livestock and link them to sustainable multiplication and delivery systems. The flagship will therefore also aim to develop business models and create public–private research partnerships for breed improvement programs. For example, partnerships with private chicken breeding improvement companies will be established in Nigeria, Ethiopia and Tanzania, while involvement of the private sector or breed associations will be explored to sustain community-based breeding programs for small ruminants in Ethiopia. Business models will also be established for the multiplication and delivery of improved genetics, including private–public partnerships and franchise models. Specific attention will be paid to ensuring that different socio-economic groups, including women and young people, are involved in, and benefit from, the establishment of business models. Experiences in this area will be exchanged with the other technology flagships.

It is clear that genetically superior livestock require not only their effective dissemination to producers but also the provision of inputs (feed, health) so they can express their full genetic potential. The provision of inputs will be achieved by packaging genetic interventions with other interventions, notably those emerging from the Livestock Health and Livestock Feeds and Forages flagships. Monitoring of adoption and intra-household benefits of these packaged interventions, and initiatives to overcome the barriers to adoption or to the equitable distribution of benefits, will be undertaken with the Livestock Livelihoods and Agri-Food Systems flagship. Similarly, continual monitoring and system refinement will be performed to ensure that the genetically improved breeds continue to meet the needs and preferences of their female and male keepers, as well as the market demands, under (potentially) changing climatic conditions.

This cluster of activities has also attracted some substantial bilateral funding and will be expected to attract more bilateral funding in the future. Again W1/W2 will be used to ensure delivery of the outputs and to support key components, while more bilateral funding is being sought.

Main research outputs

* Business models for continuous genetic gains tested and refined through public–private research partnerships and community-based programs.
* Business models for the multiplication and delivery of improved genetics.

Outcomes by 2022

1. Business models for multiplication and delivery of improved livestock genetics, to resource poor women and men livestock keepers, implemented by national research and development partners, and the private sector in 5 priority countries and other locations.

Milestones

* Business models for multiplication and delivery of improved livestock genetics implemented at pilot levels in 3 priority countries and other locations (2019).
* Data on livestock diversity and systems, through a gendered lens, used to develop or refine genetic improvement and/or conservation strategies by policymakers, national research and development partners and the private sector, in 3 priority countries and other locations (2019).

1. Women and men resource poor livestock keepers sustainably utilising improved livestock genetics, both productive and adapted, in 3 priority countries and other locations.

Milestones

* The activities of the entire flagship contribute to this ‘near’ development outcome where technologies, genetic improvement strategies, business models and policy and institutional arrangements are integrated together at pilot levels to create changes for women and men resource-poor livestock keepers.

Cluster 4: Policy and institutional support

Policies on animal genetic resource use, ownership, improvement and conservation are key to ensuring equitable benefits from livestock genetics, as well as sustainable genetic improvement.

In this cluster the flagship will support national partners by ensuring sustainability of the genetic improvement strategy and delivery systems through appropriate policies and institutional arrangements. Capacity development, training and communication initiatives will provide further support. Existing policies, legal frameworks and institutional arrangements will be reviewed, including from a gender perspective, and changes proposed and advocated. This will be done in partnership with key national stakeholders, including agencies and ministries responsible for livestock development, and in alignment with national livestock development strategies. Regional organizations, such as AU-IBAR, will also be involved, together with FAO’s Animal Production and Health Division. Initially, this work will focus on selected countries in Africa, but later it will be expanded to other African and possibly to Asian countries.

Closely linked to the other clusters of activities, W1/W2 funds will be used to develop the ‘technical’ outputs of this cluster.

Main research outputs

* Guidelines on policy and institutional arrangements for informing livestock breed/population improvement and conservation options in developing countries.

Outcomes by 2022

1. Guidelines on policy and institutional arrangements for improvement and conservation of animal genetic resources (AnGR) adopted by policymakers, national research and development partners, and the private sector, in 7 priority countries and other locations

Milestones

* Institutional arrangements supporting genetic improvement strategies and multiplication and delivery systems in place for 3 priority countries and other locations (2019).
* Guidelines on policy and institutional arrangements for improvement and conservation of AnGR adopted by at least 4 priority countries and other locations (2022).

#### 2.1.1.7 Partnerships

**Core flagship partners**: These are advanced research institutions (new technologies and new sciences), national programs (testing and use of new genotypes, new technologies and new sciences), and private-sector companies (delivery of improved livestock breeds and continuous genetic improvement strategies).

**Partners to leverage scientific comparative advantage**: To harness the necessary scientific comparative advantages, building-up on partnership already ‘piloted’ in the Livestock and Fish CRP, the flagship will further develop its strategic partnerships with leading academic institutes, though the CTLGH which combines complementary expertise from the developing and the developed worlds in the areas of livestock genomics and health. It includes research programs aiming to harness bovine and poultry tropical adaptation and disease resistance to improve productivity and to develop novel reproductive and germplasm technology in poultry. It also includes a platform for genome editing. Wageningen UR will partner on poultry research (molecular and breeding) and support the flagship’s research-oriented capacity development initiatives. SLU leads the Livestock Health flagship and accordingly will provide scientific expertise at the interface between genetics and health. It also has a strong bioinformatics team collaborating with BecA-ILRI Hub and hosts the International Bull Evaluation Service, an important delivery partner.

Through CTLGH, the program will have access to relevant research consortia, such as the International [Functional Annotation of Animal Genomics](http://www.faang.org). The flagship will also contribute to several ongoing or emerging initiatives to set up genome diversity research consortia (e.g. ‘1000K’ cattle, sheep or chicken genome projects) by contributing its livestock genome diversity data and gaining access to other genome information relevant for its activities. Flagship partners are part of the African Goat Improvement Program and the ADAPTMap Consortium. All of these provide further opportunities to interact with advanced research institutes such as Iowa State University, USDA, etc. Besides these academic research partners, the flagship will team up with private partners, including Recombinetics (for genome editing) and genome sequencing companies, such as Novogene.

**Partners for effective innovation systems in program sites**: the flagship’s partners in priority countries and locations are actors throughout the value chain. Given the multi-country focus of its activities, the flagship will continue to work with FAO and AU-IBAR, which provide overarching knowledge and policy frameworks to national program partners. It will work closely with these partners, which will be implementing genetic improvement strategies at sites. For example, in the dairy genetic improvement activities in Ethiopia and Tanzania, the partnership includes the Ethiopian Institute of Agricultural Research, the Tanzania Livestock Research Institute, and national artificial insemination centres in both countries. Together with the private sector (Genus, an artificial insemination company) and NGO partners (e.g. Land O’ Lakes), these national partners will lead in the importation, introduction and delivery of improved dairy genetics in line with national policies and livestock strategies, as well as country-endorsed international treaties.

**Partners for effective scaling as part of regional and global innovation systems and multi-stakeholder platforms**: Private-sector partners will be involved in the development of business models, but also in breeding improvement and in supporting intervention and scaling up in target countries and beyond. The flagship will identify these partners at an early stage and bring them into the design and implementation of breeding schemes. They could include, for example, subsidiaries of major chicken breeding companies (Cobb-Vantress, Aviagen, Hendrix, Hyline, etc.).

#### 2.1.1.8 Climate change

Genetic improvements can help livestock production systems adapt to and mitigate climate change. Adaptation involves reducing the vulnerability of people and ecosystems by developing genetic improvement strategies that produce resilient and productive genotypes (Hayes *et al.,* 2013). The flagship will focus on breeds that are already adapted to harsh agro-ecological conditions and aim to identify at genome level their adaptive traits linked to heat tolerance in addition to the ability to survive, grow and reproduce under conditions of poor nutrition, parasites and infectious diseases. The distribution and severity of these environmental challenges are already being altered by climate change.

Mitigation involves reducing the impact of climate change in the long term by reducing the emission of greenhouse gases per unit of animal product, through increased genetic-based productivity (e.g. lowering the number of heads required per unit of livestock commodity) and better management (especially of feed), allowing for higher reproductive potential (earlier age at first calving, shorter calving intervals) and faster growth rates, such that animals reach sale weight at an earlier age (Gerber *et al.,* 2011; Gerber *et al.,* 2013). This flagship will work closely with the Livestock and the Environment and the Livestock Feeds and Forages flagships on these issues.

#### 2.1.1.9 Gender

Understanding gender issues in genetic resource use, and designing interventions based on this understanding are critical (see Annex 3.3). Research on these issues will be done with the Livestock Livelihoods and Agri-Food Systems flagship.

Key gender issues to be addressed include (i) ensuring the participation of women and men livestock keepers in establishing genetic improvement priorities (based on their different needs, different species preferences and different priority traits), and in choosing a genetic improvement strategy (for example, considering different impacts of gender norms on participation in community-based genetic improvement programs); (ii) ensuring that chosen genetic technologies meet the different needs and preferences of women and men identified in (i), increase the benefit per unit of women’s labour expended and/or reduce women’s net labour expenditure; (iii) ensuring gender-equitable access to genetic technologies and to associated information; and (iv) addressing issues of control, for example in decision-making on genetic technologies, over access to and use of the technologies, and over any benefits resulting from their use.

Youth

The flagship recognizes that young people are not a homogenous group but will have varied appetites for participating in the genetic improvement of livestock. It will work across the CRP to ensure that interventions in livestock genetics lead to opportunities for youth entrepreneurship and employment (see Annex 3.4). Young people appreciate opportunities to make money, preferably relatively quickly and without excessive upfront investment. Areas for possible engagement, and income generation, include the keeping of genetically superior livestock, participation in livestock genetic improvement programs, recording animal performance, serving as feedback agents, developing locally relevant digital applications for extension packages, and acting as a service provider in genetic improvement and scaling up.

#### 2.1.1.10 Capacity development

The flagship has a strong capacity development component in its ToC. Capacity development is central for the flagship to take its research results to scale and ensure the sustainability of genetic interventions (see Annex 3.2).

This component will involve actors throughout the value chain in embracing new genetics and genomic science and its implications for their livelihoods. The flagship will therefore have an impact on all the capacity development sub-IDOs: Enhanced individual capacity, increased capacity for innovation in partner research organizations, increased capacity for development in partner development organizations, and enhanced institutional capacity.

The focus will be on capacity development among individuals (farmers, scientists, policy-makers), organizations (e.g. farmer communities, breed associations), national institutions (agricultural research centres, relevant academic bodies) and the local private sector. The flagship will combine traditional and novel capacity development activities, including farmer field schools**,** video, mobile applications**,** MSc/PhD training, and innovation platforms. Capacity development initiatives will draw on needs assessment and use innovative learning materials and approaches, including gender-sensitive approaches and attention to young people.

Curricula and training modules for post-graduate programs in animal breeding, genomics and genetics for African regions will be developed, building on past projects such as the Animal Genetics Training Resource. It will develop capacity development partnerships, for example with the PICO-team East Africa and with academic institutions such as SLU, Wageningen and the BecA-ILRI hub.

The CGIAR capacity development elements to be addressed are: needs assessment and intervention strategy; learning materials and approaches; development of future research leaders; gender-sensitive approaches throughout capacity development; and institutional strengthening.

#### 2.1.1.11 Intellectual assets and open access management

Robust IA management, open access and research data management and communications help in uptake and achieving outcomes (sections 1.0.12, 1.0.13 and 1.0.14 and annexes 3.8, 3.9, and 3.10.7). Specific issues relevant to this flagship are listed here.

For IA management, an important element of the flagship’s breeding work (breed multiplication) may be conducted in partnership with private companies. This will be managed through materials transfer agreements that will allow the flagship to use and disseminate the company’s products. In other cases, the focus is on community-based breeding, where the results are generated and owned by rural communities and those using the information and data must recognize farmers’ communal and legal rights. In still other cases, flagship projects collect data through partners and agreements are needed that recognize the ownership of the data by the third party and the flagship’s rights to disseminate any analysis and results from the data (with attribution). More generally, flagship activities will be guided by the Global Plan of Action for Farm Animal Genetic Resources and the [Interlaken Declaration](http://www.fao.org/3/a-a1404e.pdf), which ensures that the world’s livestock biodiversity is used to promote global food security and remains available to future generations.

Ensuring that raw data are well documented and accessible will be tackled through partner open access and data management plans. Most of the information products of the Livestock and Fish flagship are already open access. This includes materials accessible through [CGSpace](http://cgspace.cgiar.org). Additionally, the flagship will reserve funds each year to enable bilateral projects to pay article open access fees when needed. Further upstream, genome sequencing generates large amounts of data that will be put into open databases such as NCBI, while for other types of data (e.g. results of breed surveys, phenotypic information) it will make use of digital repositories such as [DRYAD](http://datadryad.org/).

#### 2.1.1.12 Flagship management

Implementation of the flagship will be led by a flagship leader (FL). The flagship core team (flagship leader and senior scientists) will develop and update the research agenda and impact pathway, as well as monitoring the quality and delivery of the outputs and reporting. The FL will lead guide priority strategic research and allocation of W1/2 resources as well as any strategic exploration of new research areas; guide development of bilateral projects to ensure alignment to the flagship their ability to contribute to strategic synthesis funded by W1/2; coordinate all reporting; lead cross-flagship initiatives; support and sometimes lead resource mobilisation and lead bi-monthly meetings (face-to-face or virtual). Senior scientists in the flagship will help develop the flagship strategy, and in particular will guide the design of research within their scientific areas of expertise. They will also monitor the science quality of outputs.

The flagship will adopt a flat management structure with ILRI and ICARDA scientists leading specific projects and contributing, within the remits of their scientific expertise and experience, to the entire flagship portfolio. The flagship will be led by Olivier Hanotte (ILRI); 20% of his time will be supported by W1/2, with 20% administrative support, and an annual Flagship meeting.

Regular (monthly) virtual flagship meetings will be held, supplemented by a yearly face-to-face meeting with all key flagship partners to reflect on lessons and re-set strategies as needed. The yearly meeting will be the opportunity for flagship members to present their scientific results.

### 2.1.2 Flagship Budget Narrative

#### 2.1.2.1 General Information

CRP Lead Centre's Name: ILRI

Centre Location of Flagship Leader: Ethiopia

#### 2.1.2.2 Summary











The flagship aims to deliver 5 targeted outcomes including a gender cross-cutting one, through clusters of activities.

Personnel costs is the main cost driver in the budget. To deliver the 5 targeted outcomes to which this flagship is aligned, a total of 42.41 FTEs/per annum are required over the 6 year life of the program (214.98 FTE in the current budget). It represents approximately 47% of the total flagship budget. These staff include Principal Investigators (Program Director/Leader, Principal Scientists, Senior Scientists, Scientists), Research support staff (Post-doctoral scientists, Research Associates/Assistants, Bio-repository Manager, Reproductive Platform Manager, Research Technicians, Technical Assistants, Field Assistants) and Administrative Support staff (Program Manager Officer (International and national), Administrative Assistant, Accountant). This number also includes new hires:

* Bioinformatician (Years 1, 2, 3 and 4 at 1.0 FTE): W3/Bilateral funding. A scientist senior position (5B level 3). This position will be implementing and leading the daily bioinformatics operations that underpin bilateral/window 3 projects.
* Linux Systems Administrator (Informatics) (Year 1: 0.5 FTE, Year 2: 0.5 FTE, Year 3: 0.25 FTE, Year 4: 0.25 FTE): W3/Bilateral funding. A national recruited staff based at ILRI - Nairobi. This systems administrator will be responsible for both hardware and system-level software that underpin all of the informatics needs of all of the Animal Genetics Flagship Project.
* A Post-Doctoral Bioinformatic position (Years 1, 2, 3 at 1.0 FTE): W1/W2 funding. This full-time position will be expected to lead the bioinformatic analysis at ILRI – Addis Ababa, more particularly in relation to the analysis of full genome sequences analysis from different projects. Initially, funded by W1/2 for a maximum of three years it is expected to be supported through bilateral/W3 project in subsequent years.
* A Post-Doctoral Quantitative/Animal Breeding position (Years 1, 2, 3, 1.0 FTE). W1/W2 funding. Based at ILRI – Nairobi. This full-time position will be expected to support the quantitative/molecular and animal breeding analysis of all relevant flagship not predominantly funded by W3/bilateral funding. This is therefore a strategic position for the flagship in support of activities currently, deemed essential for the delivery its outcome target but currently poorly funded by bilateral funding (e.g. pig breeding in Uganda/Vietnam, cattle dairy West Africa).
* An Animal Scientist (Years 1, 2, 3 at 1.0 FTE). W1/W2 funding. Based at ILRI – Addis, this person will be leading the development of ILRI – DAGRIS (Domestic Animal Genetic Resources Information System), currently on-hold following the decline in W1/W2 funding for the Phase 1 Livestock and Fish CRP). It will be funded by W1/W2 for a maximum, of three years, in subsequent years, it is expected to be supported through bilateral/W3 project funds (e.g. 10K Livestock Genome project).

Delivery of Outcome 1 (790,000 , 20,000 , 20,000 and 115,000 livestock keeping households (representing 3.7 million , 84,000 , 115,000 and 600,000 individuals, respectively) realizing a 30-50% increase in income, on average, of the household enterprise from chicken, pigs, small ruminant and dairy cattle, respectively, through the use of genetically improved livestock combined with other appropriate animal husbandry practices, across 5 countries will require approximately 30% ($7,600,000) of the flagship's W1/W2 allocation. A total of 45.72 FTEs is required over the life of the program at a cumulative cost of approximately $5,000,000. Skill categories here include animal geneticists, animal breeders, animal systems specialists, agricultural economists, capacity development specialists. No new hires are required for this outcome.

Lesser amounts of W1/W2 budget are assigned to operational costs (travel, capital equipment and supplies and services) associated with delivering this outcome. Included here are the budget for communication, open data access and data management. A small travel budget of about $30,000 is required for visits to partner institutions, attendance to country meetings, capacity development activities and field sites visits and activities.

Bilateral funding to the value of about $5,000,000 also supports the achievement of Outcome 1. Of this amount, approximately 30% is budgeted for personnel, representing a total of 18.92 FTEs over the life of the program. No new staff will be hired on bilateral funding. Smaller amounts of the projected bilateral funding are assigned to operational costs, namely $176,000 for essential within country travel, $146,000 for supplies and services (consultancy cost for baselines studies and review of protocols). No bilateral funding is allocated to capital equipment for this outcome.

Outcome 2 (1.5 million, 40,000, 45,000 & 230,000 livestock keeping households realizing an 20-25, 20-25, 5 and 20-25% increase in productivity, on average, for chicken, pigs, small ruminants, and dairy cattle, respectively, through the use of genetically improved livestock combined with other appropriate animal husbandry practices, across 5 countries) will require approximately 15% ($3,800,000) of the flagship's W1/W2 allocation, including 22.85 FTEs over the life of the program at a cumulative cost of just over $2,5M. Skill categories here include animal geneticists (molecular and quantitative), animal breeders, bioinformatician and animal geneticists, animals breeders. 3.00 FTEs of new hires (bioinformatics, quantitative geneticists) are required.

Lesser amounts of W1/W2 budget are assigned to operational costs (travel, capital equipment and supplies and services) associated with delivering this outcome. Included in the supplies and services line items are major funding for Genomic and Phenomic approaches as well as the analytical platforms, namely $1,1M. A travel budget of about $150,000 is required for visits to partner institutions, attendance to country meeting, capacity development activities and field sites visits and activities as well as the livestock industry advisory meeting.

Bilateral funding to the value of approximately $2,5 million also supports the achievement of Outcome 2. Of this amount, approximately 15% is budgeted for personnel, representing a total of 9.46 FTEs over the life of the program. 2.75 FTE will be hired on bilateral funding in order to have capacity in bioinformatics and database management.

The following amounts of the projected bilateral budget are assigned to operational costs, namely about $90,000 for travel is required for project inception and annual planning meeting, inter-country and in country meetings. $520,000 for laboratory supplies and genotyping expenses and $109,000 for capital equipment (for on-site recording of performance of livestock performance, laptop and country computing servers).

Outcome 3 (1.5million, 40,000, 45,000 and 230,000 livestock keeping households realizing an 50-100, 25-50, 6-12 and 50-100% increase in genetic gain, on average, for chicken, pigs, small ruminants, and dairy cattle, respectively, through the use of genetically improved livestock, across 5 countries will require 15% ($3,802,000) of the flagship's W1/W2 allocation, including a total of 22.87 FTEs over the life of the program. Skill categories include animal geneticists (molecular and quantitative), animal breeders, bioinformatician and animal geneticists. Three FTEs of new hires (bioinformatics, quantitative geneticists) are required.

Lesser amounts of W1/W2 budget are assigned to operational costs (travel, capital equipment and supplies and services) associated with delivering this outcome. Included in the supplies and services line items are major funding for the reproduction platform at $550,000. A travel budget of about $150,000 is required for visits to partner institutions, attendance to country meeting, capacity development activities and field sites visits and activities as well as meeting with breeding companies.

Bilateral funding to the value of almost $2,5M also supports the achievement of Outcome 3. Of this amount, approximately 15% is budgeted for personnel, a total of 9.46 FTEs over the life of the program. 2.75 FTE will be hired on bilateral funding in order to have capacity in bioinformatics and databases management. The following amounts of the projected bilateral budget are assigned to operational costs, namely $88 000 for travel is required for project inception and annual planning meeting, inter-country and in country meetings. $520.778 for supplies and services (laboratory supplies and genotyping cost) and $110,000 for capital equipment (for on-site recording of performance of livestock performance, laptops and country computing servers).

Delivery of Outcome 4 (Guidelines on policy and institutional arrangements for informing breed improvement and conservation options adopted by policy-makers and/or national research partners for one or more species in 4 countries, influencing the practices of 2.2 million livestock keeping households), will requires 20% of the flagship's W1/W2 allocation, including 31.36 FTEs over the life of the program with the following skill categories - animals breeders, animals systems scientists and capacity development specialists. Three FTEs of new hires (Animal Scientist DAGRIS) are required.

Lesser amounts of W1/W2 budget are assigned to operational costs (travel, capital equipment and supplies and services) associated with delivering this outcome. Included in the supplies and services line items are major funding for the bio-repository platform at about $500,000. Capital equipment supported by W1/W2 funds included computer servers and workstations at $200,000. A travel budget of $200,000 is required for visits to partner institutions including international (FAO) and regional partners (AU-IBAR) attendance to country meeting and capacity development activities.

Bilateral funding to the value of $2,977,000 also supports the achievement of Outcome 4. Of this amount, approximately 18% is budgeted for personnel, representing a total of 11.27 FTEs over the life of the program. No FTE will be hired on bilateral funding. Operational costs include only travel costs (about $100,000 for within countries meeting with policy makers, meeting at the country ministries, capacity development including training workshops) and a total of approximately $600,000 for supplies and services (support for activities leading of the delivery outcome 1, 2 and 3).

Outcome 5 (3.6 million; 50,000; 70,000 and 230,000 women, across 5 countries, enjoy 5-10% increase in returns to their labour, on average, for chicken, pigs, small ruminants and dairy cattle, through the use of genetically improved livestock combined with other appropriate animal husbandry practices) absorbs 20% ($5,067M) of the flagship's W1/W2 allocation, including 30.48 FTEs over the life of the program. The main skill categories here include gender and capacity development specialists beside animal geneticists (molecular and quantitative) and animal breeders. Budget provision has been made for input from the ILRI Gender unit.

Lesser amounts of W1/W2 budget are assigned to operational costs (travel and supplies and services) associated with delivering this outcome. Included in the supplies and services line item are e.g., field operation inputs (e.g., survey material), consultant's fees for gender and capacity development as well as surveys. A travel budget of $200,000 is required for sites visits, field work, demand prioritization, participation in national and international conferences.

Bilateral funding to the value of just over $1,000,000 also supports the achievement of Outcome 5. Of this amount, approximately 5% is budgeted for personnel, a total of 12.61 FTEs. ﻿The following amounts of the projected bilateral budget are assigned to operational costs, namely: $120,000 for travel for field work, participation in international meetings and conferences; $700,000 for supplies and services (surveys, materials, capacity development).

Management of the Flagship (W1/W2) is budgeted at 20% of the Flagship Leader’s time while smaller amounts are provided for other management staff such as a Program Management Officer and a Program Accountant. Also, all major flagship bilateral projects benefit from the input of a Program Manager Officer or Senior Administrative assistant, full time FTE 1.0) or part-time in the case of smaller, bilaterally-funded projects to provide overall administrative, financial and human resource support. The remaining of the cost of the flagship leader is covered through bilateral funding. The management costs are pro-rated across the outcomes.

#### 2.1.2.3 Additional explanations for certain accounting

For the CGIAR partners, personnel costs are defined as the total remuneration costs of an individual: base salary, fringe benefits and other employment costs. Actual computations on average for fringe benefits and employment costs in relation to base salary would translate to an average multiplier of 97% and 68% for international and national staff respectively. The reason for the higher average multiplier for international staff is because of the housing allowance, security and education allowance that are not provided to nationally recruited staff. Fringe benefits include: pension, housing allowances, education allowance, security, health insurance, other insurances, catastrophe fund, annual leave and severance pay. Other employment related costs include staff training and development; transportation, recruitment, appointment and repatriation allowances and payroll administration fees.

For SLU, the 51.3% fringe benefits is constituted as a Swedish tax that the employer must set aside for the employees and covers vacation, sick-leave, parental leave, part of the pension, full professional insurance and part of health care costs. ﻿﻿

The cost structure of research undertaken during the first phase CRPs has been applied to estimate the average research costs for collaborators, consumables, other supplies and services, and travel. The actual cost structure for secured W3/bilateral projects is first applied, and the average research cost factors are then applied to the remaining portions of the budget yet to be secured. The laboratory cost estimates are based on the cost estimates provided by the BecA-ILRI Hub in providing these range of laboratory services to current Hub users in ILRI - Nairobi, for ILRI - Addis it is based on CRP Livestock and Fish current cost, but it should be noted that these may change following the opening of a new biotechnology lab at ILRI- Addis Campus.

#### 2.1.2.4 Other Sources of Funding for this Project

This flagship is funded by a mix of W1/2 and W3/bilateral funding. Funding from W3 and bilateral sources is fully secured for Year 1 and under the base budget scenario and to a large extend for Year 2 and Year 3. Years 4, 5, 6 will require new W3 and/or bilateral funding.

Cash and in-kind funding: Partners provide substantial cash or in-kind funding. For example (i) flagship activities in China benefit from cash and in-kind support from the Chinese Academy of Agricultural Science for housing, laboratory supplies and consumables at an estimated cost of $45,000 year; (ii) for the African Chicken Genetic Gains (ACGG), an additional $3,385,906 mainly in-kind funding has been secured from partners. This includes $1,059,606 from ILRI (office space, ICT and research coordination costs that are not covered by the donor, $710,000 from the Ethiopian Government, $420,000 from the Nigerian Government, $650,000 from the Tanzanian Government, $101,500 from Wageningen UR and $44,800 from PICO East Africa. The Koepon Foundation has committed $400,000 in cash; (iii) similarly for the African Dairy Genetic Gains (ADGG) project, also supported by the Bill and Melinda Gates foundation, ILRI will provide in-kind contributions US$ 254,699 (US$ 85,766 in Year 1 and US$ 94,063 in Year 2); the University of New England provides in-kind support of $309,810 (Year 1 and 2); (iv) the Centre for Tropical Livestock Genetics and Health (CTLGH) will cover the balance of the overheads on the flagship staff time funded by the Bill and Melinda Gates foundation at a total amount of $ 719,890 (total for Years 1, 2, 3, 4).

New funding initiative: Recognizing the high degree of uncertainty with W1/2 funding, both in terms of whether the indicative allocation assigned to the CRP in the CRP2 guidance document will be maintained once the CRP portfolio has been approved, and in terms of whether the projected budget assigned to the CRP in the System Financial Plan each year is actually achieved through donor W1/2 commitments, the program will be prepared to reduce the scope of its activities and outcomes to reflect any W1/2 funding shortfalls, especially after Year 3. The flagship’s strategy is to maintain a minimum of capacity (molecular, breeding, quantitative genetics, socio-economist etc.) to ensure outcomes are delivered. It will scale down activities by focusing on a smaller number of project sites rather than eliminating any cluster of activities as they are all interlinked and needed to deliver outcomes.

In addressing such a scenario, high priority will be given to mobilise bilateral funding to implement the full program and achieve the outcomes.

Two fully-funded bilateral projects are in the pipeline: A TCP submitted to FAO “Regional cooperation for conservation, improvement and sustainable utilization of sheep and goats genetic resources affected by the ongoing crisis in West Asia” , $0.5M (anticipated start date 2017) and a project submitted to the OCP Foundation on ‘Tapping camel genetic resources to build resilience and improve livelihoods of pastoralists in the Horn of Africa and North Africa regions’ $0.75M (anticipated start date 2017). While the former will geographically expand the scope of flagship activities, the latter represents an important pilot project exploring the importance of a ‘non-traditional’ animal genetic flagship species.

This flagship has also identified the following two new major projects to address the need for replacement funding as current projects end insuring that priority targets and outcome are delivered and to secure resources for the uplift budget scenario.

1. Funds will be sought for a major new initiative to sequence the genomes of all currently recognized livestock breeds. Called the 10K livestock genomes project, it will have a very strong capacity development component to empower national livestock research institutions in bioinformatics and genomics, Expected outputs will respond to the needs and demands from these institutions for scientific knowledge (genome sequences data and their analysis) to facilitate the prioritization of breed conservation. This project will directly contribute to sub-IDO, increase conservation and use of genetic resources by providing a catalogue of the genetic diversity present in a livestock breeds (in silico ex-situ diversity conservation) and a catalogue of candidate functional polymorphisms linked to genome signature of adaptive traits in the same population opening the door to marker-assisted improvement of productivity and genome editing. It will also contribute to sub-IDOs Enhanced genetic gain and Close yield gaps to improve agronomic and animal husbandry practices. It is therefore linked to increased productivity. Expected project outcomes are: (i) Distributed in silico gene bank of livestock genetic diversity; (ii) sustainable improvement of livestock productivity with breeding programs using genome diversity information (e.g. marker-assisted selection, genome editing); (iii) identification of livestock pathogens and commensal reservoirs, including zoonotic species; (iv) new understanding of genome function and new sources of diversity for developed world breeds; (v) genome analysis capacity embedded in developing countries. Initially, funds will be sought for a pilot study involving 100 breeds/ecotypes from each of 3 ruminant species (cattle, sheep, goats) plus chickens, sampled across 10 African countries at an approximate cost of $3.7M. The flagship expects the pilot to start in 2018. The eventual target is to sequence some 10,000 livestock breeds/ecotypes from 9 species (cattle, sheep, goats, chickens, pigs, yak, buffalo, dromedary, yak) with an approximate total cost of around $70M. This project will represent an extraordinary value in terms of knowledge and capacity embedded into developing country systems and genomic understanding to secure the future of livestock productivity in a rapidly changing world.

2. A second major initiative is the development of a Long Term Genetic Gain Program (LTGG) to follow-up the already-funded African Chicken Genetic Gains (ACGG) and African Dairy Genetic Gains (ADGG) projects focusing on tropically-adapted and farmer preferred chickens and dairy cattle for sustainable productivity growth. The project will be a research for development initiative jointly designed by the Animal Genetics flagship, National Agricultural Research Systems, and private chicken and dairy cattle breeding companies. The program will aim to set-up (i) a long term and sustainable genetic gains program, using farmer preferred strains (chickens) and optimal agro-ecosystems dairy x indigenous cattle crossbred as base population, using the National Agricultural Research System and/or private sector breeding facilities to continually improve poultry strain productivity and dairy crossbreed productivity; (ii) establish a multiplier flock (chickens) and delivery AI system (crossbreed dairy cattle) through a network of hatcheries/multipliers or artificial insemination centres that should become self-sustaining and functioning in the long-term. Piloting of these activities are included in the current ACGG and ADGG projects but they will need to be scaled and sustainability mechanisms will need to be put in place. The target is to increase the productivity level by 2% annually (e.g. eggs and/or milk production).The estimated budget for the first five-year period is $20M each for the chicken and the crossbred dairy cattle projects, starting from 2019/2020 onwards.

|  |  |  |
| --- | --- | --- |
| Project focus | Total amount ($) | Start Year |
| Conservation, improvement and sustainable utilization of sheep and goats genetic resources in West Asia  Camel genetic resources to build resilience and improve livelihoods of pastoralists in the Horn of Africa and North Africa regions  10K livestock genomes project (Pilot phase Africa) | 0.5M    0.75M    3.7M | 2017    2017    2018 |
| Long Term Genetic Gain Program (LTGG) chicken | 20M | 2020 |
| Long Term Genetic Gain Program (LTGG) dairy cattle | 20N | 2020 |
| TOTAL FUNDING GAP | 26,950 M |  |

#### 2.1.2.5 Budgeted Costs for certain Key Activities

|  |  |  |
| --- | --- | --- |
|  | **Estimate annual average cost (USD)** | **Please describe main key activities for the applicable categories below, as described in the guidance for full proposal** |
| Gender | 2,280,502 | Funding for gender activities are from two sources: First is gender-specific funds, this includes a gender post-doc position (FTE 1.0) for Year 1, as well as support for a Gender Scientist position (W1/W2, FTE 0.20) over the six years CRP period. The second source is bilateral Funding related to gender supports a national staff gender specialist position (FTE 0.10) over years 1, 2, 3. |
| Youth (only for those who have relevant set of activities in this area) | 90,000 | Areas for possible engagement include income generation, include the keeping of genetically superior livestock, participation in livestock genetic improvement programs, recording animal performance, serving as feedback agents, developing locally relevant digital applications for extension packages, and acting as a service provider in genetic improvement and scaling up. |
| Capacity development | 1,544,424 | Capacity development activities have a strong gender focus and the CRP estimates that half of the CapDev budget is linked to gender-related activities. |
| Impact assessment | 0 | Funding for Impact Assessments is managed out of the Strategic Investment Fund. |
| Intellectual asset management | 2,721 | A small budget has been set aside for ad hoc IP advice and support for contract development. This will be supported by in-kind investments of the partners and support from management level. |
| Open access and data management | 253,816 | The budget is allocated to covering costs of open access. Since some journal articles are limited access and the flagship will reserve funds each year to supplement bilateral projects to pay article open access fees. The flagship has allocated funds on an annual basis to ensure proper curation and publishing, including inputs to research quality and design. |
| Communication | 58,270 | The budget covers staff time as well as direct costs to ensure effective communication of its results. Bilateral projects in this flagship are expected to budget for these activities. |

#### 2.1.2.6 Other

Overall, there are relatively few risks for the flagship to operate within the proposed budget. There are risks associated with the complex and dispersed nature of the project which makes costing and monitoring potentially challenging and will require monitoring and flexibility. The CRP will attempt to reduce the level of interdependence among activities while maximizing their synergies. These issues place a significant responsibility on the flagship team to monitor execution and to coordinate and communicate as rapidly as possible. All members of the project have worked together and the senior leadership team is experienced in managing projects of this scale and complexity. The most common cause of delay is associated with recruitment but in the case of this flagship the key personnel are already identified and/or in place. However, this risk is likely different across the different parts of the Flagship. For example, recruitment may be difficult for certain skill sets, e.g bioinformatic positions, as people with such skills are in high demands worldwide. The flagship’s partnerships with advanced research institutions delivering bioinformatic courses will mitigate against such risk.

A major risk is around sub-grantees not delivering their outputs. The CRP plans to mitigate the risk by working closely with partners to ensure that milestones are being met and budgets are properly managed. Sub-grantees will be required to report to standard and frequently against milestones, and regular reporting and joint meetings will be used to ensure progress, fiduciary, and administrative compliance. Project burn rates will be discussed in the flagship monthly meetings to ensure that there is minimal disruption to the work.

### 2.1.3 Flagship Uplift Budget

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **2022 additional outcome description** | **Amount needed ($)** | **W1 + W2 (%)** | **W3 (%)** | **Bilateral (%)** | **Other (%)** |
| Livelihood Opportunities - Additional West African country for dairy cattle (Senegal), India for small ruminants and Nepal for chicken; 3 additional African countries for chicken (Uganda, Cameroon, Burkina Faso), two additional African countries in dairy (Kenya, Uganda) and two additional countries in goats (Tanzania and Malawi) | 12,597,000 | 0 | 0 | 100 | 0 |
| increased genetic gain - Additional West African country for dairy cattle (Senegal), India for small ruminants and Nepal for chicken; 3 additional African countries for chicken (Uganda, Cameroon, Burkina Faso), two additional African countries in dairy (Kenya, Uganda) and two additional countries in goats (Tanzania and Malawi) | 6,298,500 | 0 | 0 | 100 | 0 |
| Closed yield gap - Additional West African country for dairy cattle (Senegal), India for small ruminants and Nepal for chicken; 3 additional African countries for chicken (Uganda, Cameroon, Burkina Faso), two additional African countries in dairy (Kenya, Uganda) and two additional countries in goats (Tanzania and Malawi) | 6,298,500 | 0 | 0 | 100 | 0 |
| Reduced labour for women - Additional West African country for dairy cattle (Senegal), India for small ruminants and Nepal for chicken; 3 additional African countries for chicken (Uganda, Cameroon, Burkina Faso), two additional African countries in dairy (Kenya, Uganda) and two additional countries in goats (Tanzania and Malawi) | 8,398,000 | 0 | 0 | 100 | 0 |
| Conservation of genetic resources - Additional 8 countries | 8,398,000 | 0 | 0 | 100 | 0 |

1. 4 Today, the cost for re-sequencing at 10 x coverage a mammalian livestock around USD 700-800, and around USD 25 for a bird genome (Novogene and Macrogen quotations, February 2016). [↑](#footnote-ref-1)
2. 5 University of Edinburgh, Wageningen UR, University of Nottingham are all classified within the 1% top best academic institutions in [worldwide rankings](http://www.topuniversities.com/qs-world-university-rankings)). [↑](#footnote-ref-2)